BIOLOGY Life on Earth
WITH PHYSIOLOGY Tenth Edition

Audesirk Audesirk Byers

26
Population Growth and Regulation

Lecture Presentations by
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Chapter 26 At a Glance

- 26.1 How Does Population Size Change?
- 26.2 How Is Population Growth Regulated?
- 26.3 How Are Populations Distributed in Space and Age?
- 26.4 How Is the Human Population Changing?

26.1 How Does Population Size Change?

- A **population** consists of all the members of a particular species that live within an **ecosystem**, a defined geographical area
- Each population forms an integral part of a larger **community**, defined as a group of interacting populations

26.1 How Does Population Size Change?

- The **biosphere** is the enormous ecosystem that encompasses all of Earth's habitable surface
- **Ecology** is the study of the interrelationships of organisms with each other and with the nonliving environment

26.1 How Does Population Size Change?

- Changes in population size result from natural increases and net migration
  - Population size changes through
    - Births
    - Deaths
    - Net migration

26.1 How Does Population Size Change?

- Changes in population size result from natural increases and net migration *(continued)*
  - The **natural increase** of a population is the difference between births and deaths
    - Natural “increase” can be negative (decrease) if deaths exceed births
    - The net migration of a population is the difference between **immigration** (migration into the population) and **emigration** (migration out)

26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - The **growth rate** (*r*) of a population is the percentage change in the population size per unit time
  - The population growth rate is the **birth rate** (*b*) minus its **death rate** (*d*)
    - *r* (growth rate) = *b* (birth rate) - *d* (death rate)

26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - If the birth rate exceeds the death rate, the population growth rate will be positive and population size will increase
  - If the death rate exceeds the birth rate, the growth rate will be negative and the population size will decrease

26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - Population growth (*G*), which is the number of individuals added to a population in a given time period, can be calculated by multiplying growth rate (*r*) by the original population size (*N*)
    - Population growth (*G*) = *r* (growth rate) × *N* (population size)

26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - If births exceed deaths, exponential growth occurs
    - A constant growth rate (*r*) produces exponential growth
    - During **exponential growth**, an ever-larger number is added to the population during each succeeding time period

26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - If births exceed deaths, exponential growth occurs
    - This pattern of growth will occur in any population in which each individual, on average over the course of its life span, produces more than one offspring that survives to reproduce
    - If the size of an exponentially growing population is graphed against time, a characteristic shape called a **J-curve** will be produced

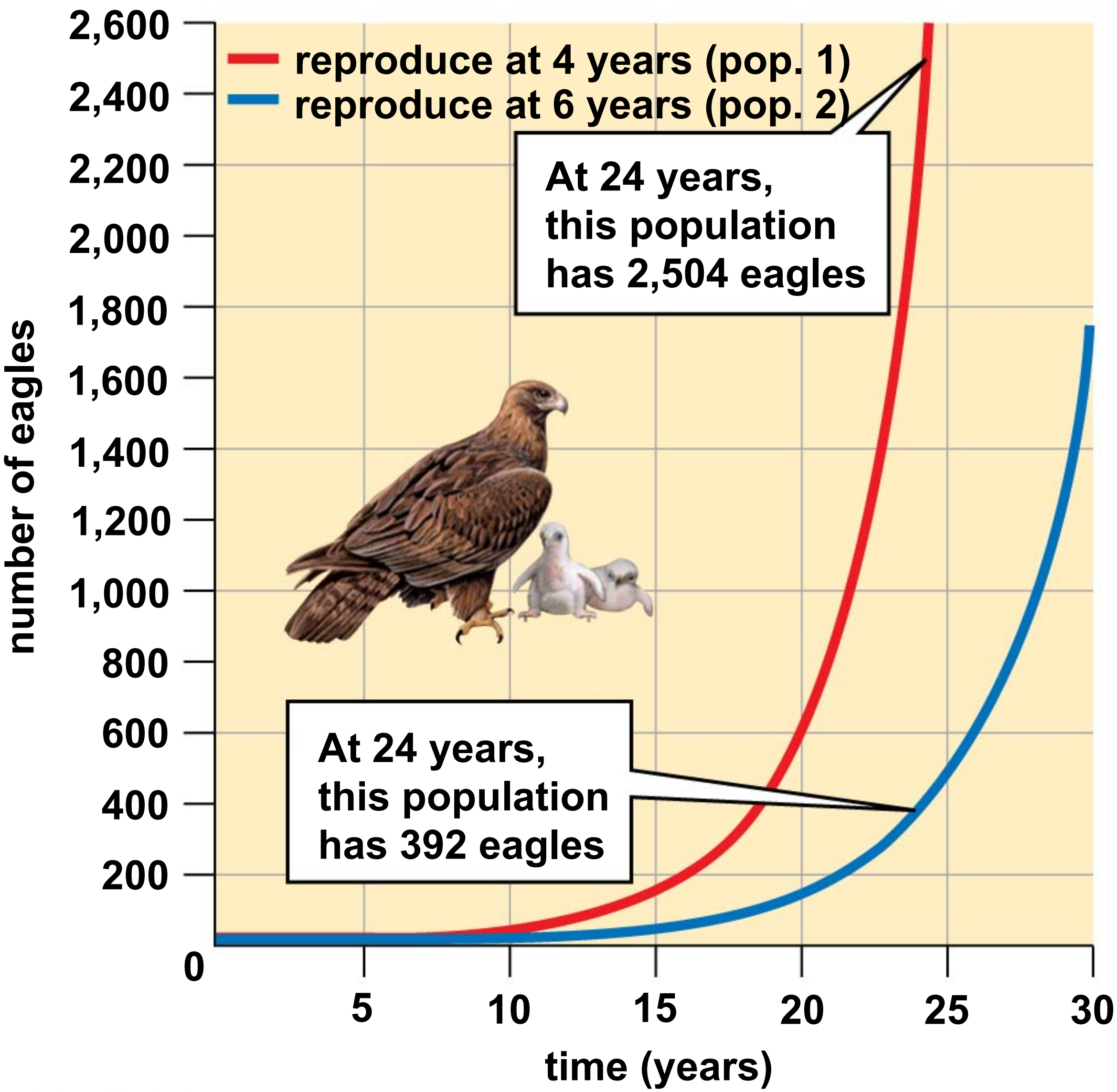
26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - If births exceed deaths, exponential growth occurs *(continued)*
    - For example, consider two populations of golden eagles that are followed for 30 years
      - Individuals in one population begin reproducing at the age of 4 years
      - Individuals in the other population begin reproducing at age 6 years

26.1 How Does Population Size Change?

- Populations grow based on the birth rate, the death rate, and the population size *(continued)*
  - If births exceed deaths, exponential growth occurs *(continued)*
    - Both populations will follow a J-shaped population growth curve, but more individuals will be added to the earlier reproducing population, resulting in a steeper increase in population numbers
    - At 30 years, the earlier reproducing population would be 10 times the size of the other population

Figure 26-1 Exponential growth curves are J-shaped



Time (years)	Number of eagles (pop. 1)	Number of eagles (pop. 2)
0	2	2
6	8	4
12	52	18
18	362	86
24	2,504	392
30	17,314	1,764

26.1 How Does Population Size Change?

- Biotic potential determines the maximum rate at which a population can grow
  - The ability to produce many offspring is an inherited attribute
  - Natural selection favors organisms whose attributes adapt them to their environments and who pass these adaptations on to as many healthy offspring as possible
  - **Biotic potential** refers to the maximum rate at which a particular population could increase

26.1 How Does Population Size Change?

- Biotic potential determines the maximum rate at which a population can grow *(continued)*
  - Several factors influence biotic potential
    - The age at which the organism first reproduces
    - The frequency of reproduction
    - The average number of offspring produced each time
    - The length of the organism's reproductive life span
    - The death rate of individuals

26.2 How Is Population Growth Regulated?

- In 1859, Charles Darwin wrote: "There is no exception to the rule that every organic being naturally increases at so high a rate, that if not destroyed, the Earth would soon be covered by the progeny of a pair."

26.2 How Is Population Growth Regulated?

- Population size results from the interaction between biotic potential and **environmental resistance**, or all the curbs on population growth imposed by the living and nonliving environment
  - Examples include interactions among organisms such as predation and competition for limited resources
  - Environmental resistance also includes natural events such as freezing weather, storms, fires, floods, and droughts

26.2 How Is Population Growth Regulated?

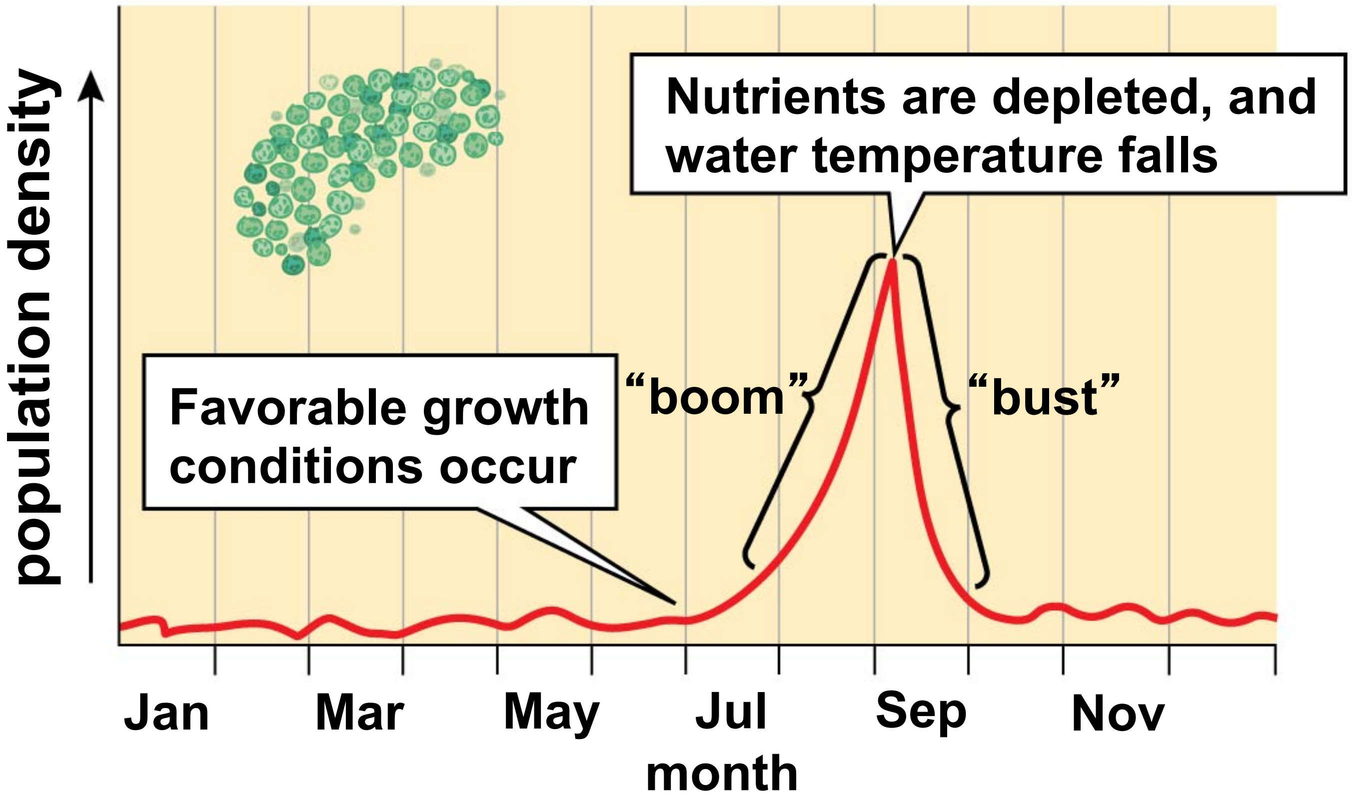
- Exponential growth only occurs under unusual conditions
  - Under unusual and temporary circumstances, natural populations exhibit exponential growth, producing J-shaped growth curves

26.2 How Is Population Growth Regulated?

- Exponential growth only occurs under unusual conditions *(continued)*
  - Exponential growth occurs in populations with boom-and-bust cycles
    - Exponential growth can be observed in populations that undergo **boom-and-bust cycles**, in which periods of rapid population growth are followed by a sudden, massive die-off

26.2 How Is Population Growth Regulated?

- Exponential growth only occurs under unusual conditions *(continued)*
  - Exponential growth occurs in populations with boom-and-bust cycles *(continued)*
    - For example, each year, photosynthetic bacteria in a lake may exhibit exponential growth when conditions are ideal, but crash when they have depleted their nutrient supply



(a) A boom-and-bust cycle in photosynthetic bacteria

26.2 How Is Population Growth Regulated?

- Exponential growth only occurs under unusual conditions *(continued)*
  - Exponential growth occurs temporarily when environmental resistance is reduced *(continued)*
    - Exponential growth can occur when individuals invade a new habitat with little competition
    - **Invasive species** are organisms with a high biotic potential that are introduced into ecosystems where they did not evolve and where they encounter little environmental resistance

26.2 How Is Population Growth Regulated?

- Exponential growth only occurs under unusual conditions *(continued)*
  - Exponential growth occurs temporarily when environmental resistance is reduced *(continued)*
    - When they are introduced into a new ecosystem, population numbers may explode due to a lack of natural predators

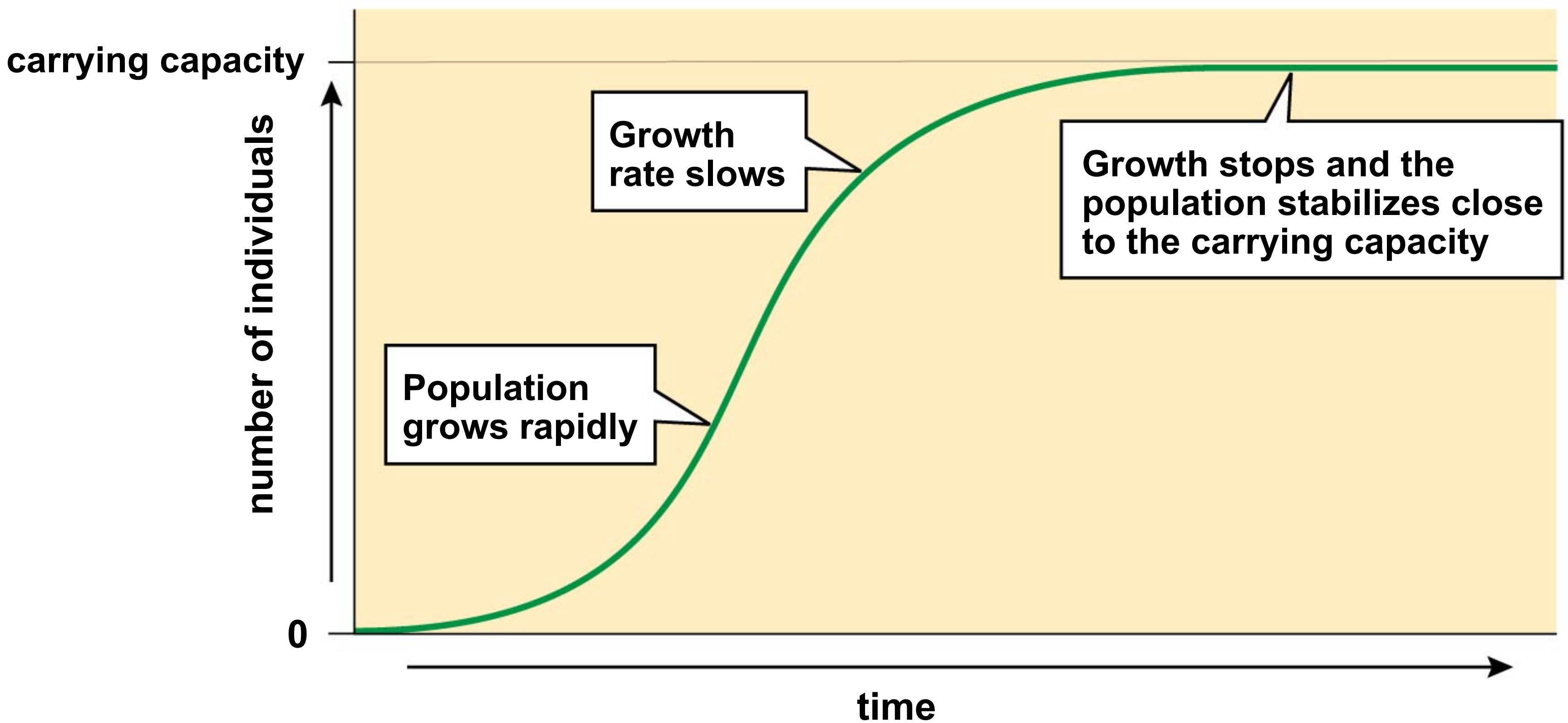
26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth
  - Many populations that exhibit exponential growth eventually stabilize to match the resources available to support them
    - As resources become depleted, reproduction slows and the growth rate eventually drops to zero, causing the population size to remain constant

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance
    - This growth pattern, where populations increase to the maximum number sustainable by their environment and then stabilize, is called **logistic population growth**
    - The maximum population size that can be sustained by an ecosystem for an extended time without damage to the ecosystem is called its **carrying capacity *(K)***

Figure 26-5a An S-shaped growth curve stabilizes at carrying capacity



(a) An S-shaped growth curve stabilizes at carrying capacity

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - When logistic growth is plotted, it results in an **S-shaped** growth curve, or S-curve
    - In nature, an increase in population size (*N*) above carrying capacity (*K*) can be sustained for a short time

Author Animation: Population Growth and Regulation

PLAY Animation: Population Growth and Regulation

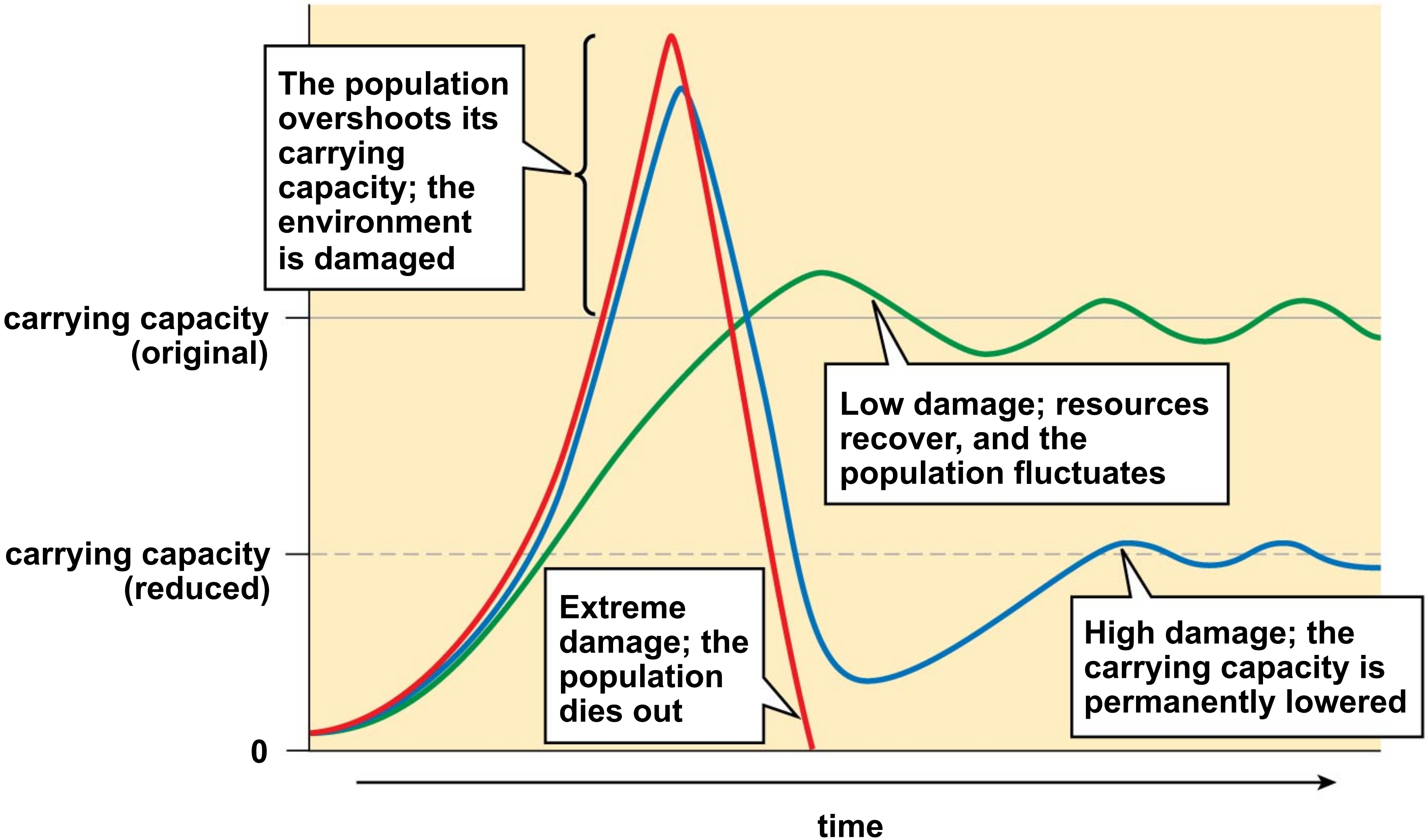
26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - If a population far exceeds the carrying capacity of its environment, excess demands placed on the ecosystem are likely to destroy crucial resources

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - This can permanently and severely reduce carrying capacity, causing the population to decline to a fraction of its former size or disappear entirely

Figure 26-5b Consequences of exceeding carrying capacity

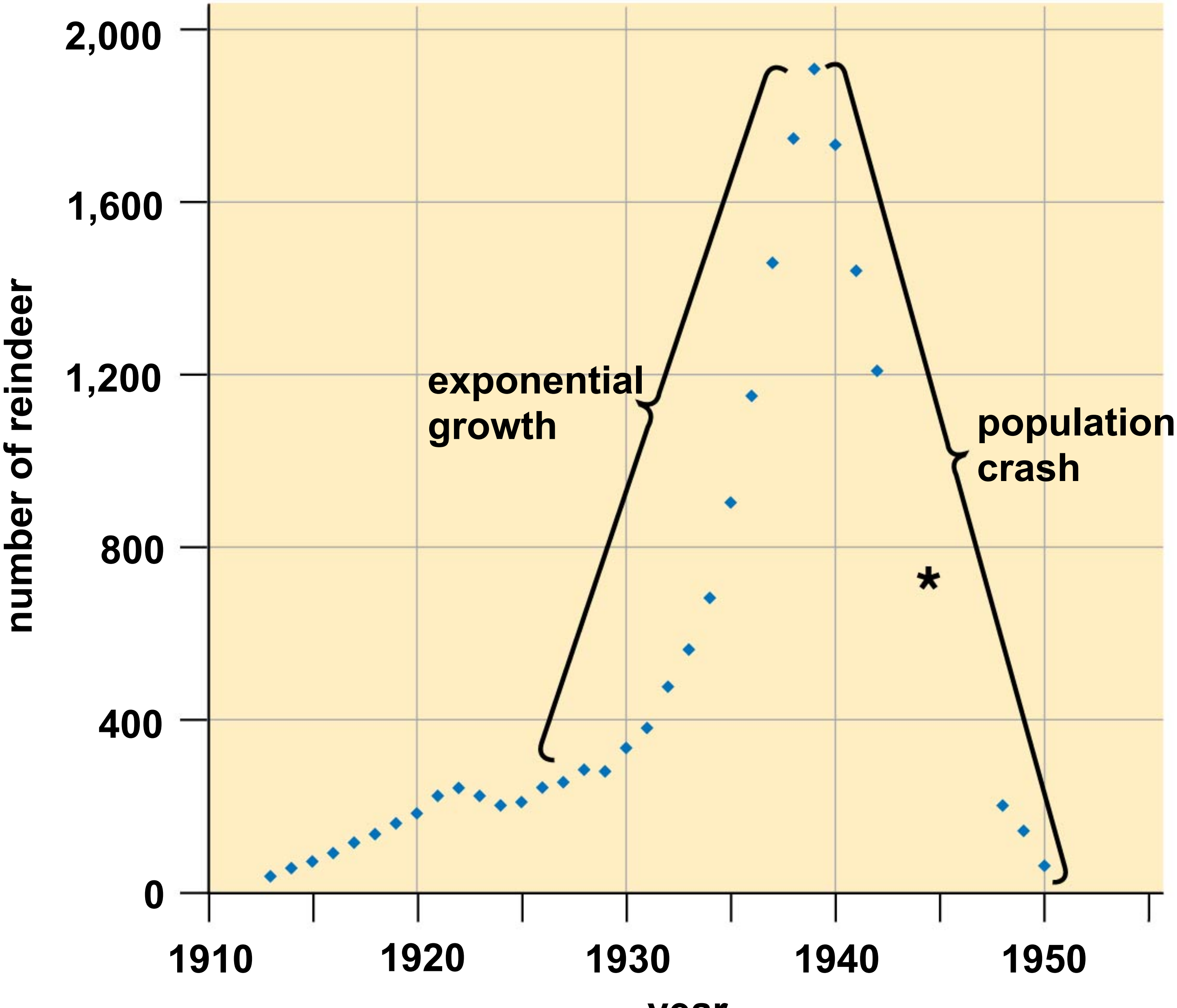


(b) Consequences of exceeding carrying capacity

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - For example, when reindeer were introduced onto an island with no large predators, their population increased rapidly, seriously overgrazing the vegetation they relied on for food
      - As a result, the reindeer population plummeted

Figure 26-6 The effects of exceeding carrying capacity



*Data not taken for 1943–1946

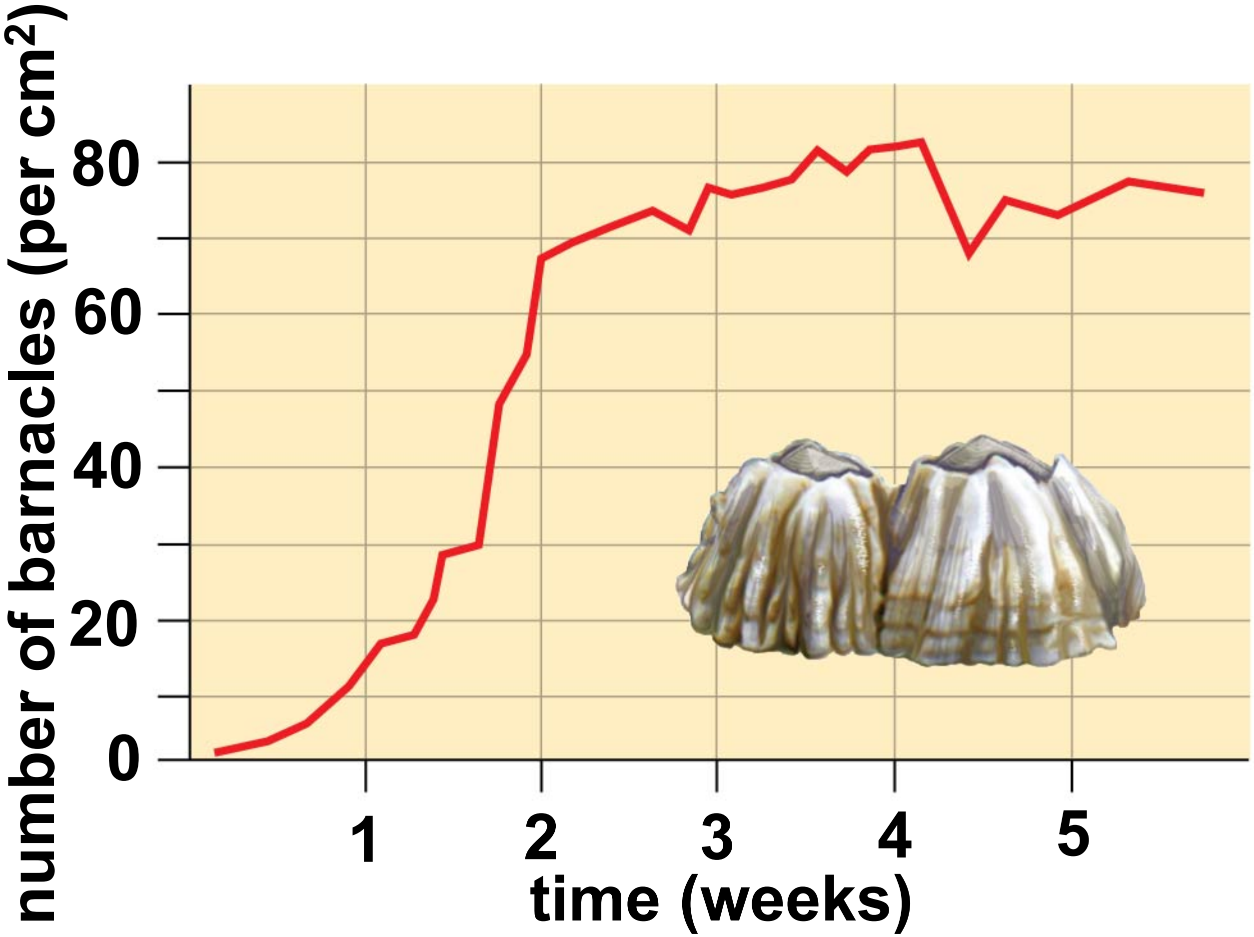
26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - Logistic population growth can occur in nature when a species moves into a new habitat
      - For example, new barnacle settlers along a rocky coast may find ideal conditions that allow their population to grow exponentially

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - Logistic population growth can occur in nature when a species moves into a new habitat *(continued)*
      - As population density increases, however, individuals begin to compete for space, energy, and nutrients

Figure 26-7 A logistic curve in nature



26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - Two forms of environmental resistance usually maintain populations at or below the carrying capacity of their environment
      - Density-independent
      - Density-dependent

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Logistic growth occurs when new populations stabilize as a result of environmental resistance *(continued)*
    - **Density-independent factors** limit population size regardless of the population density
    - **Density-dependent factors** increase in effectiveness as the population density increases

Figure 26-8a Predators often kill weakened prey

(a) Predators often kill weakened prey

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Predators exert density-dependent controls on populations *(continued)*
      - Predation becomes important as prey populations grow because predators eat a variety of prey, depending on what is most abundant and easiest to find

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Predators exert density-dependent controls on populations *(continued)*
      - Predator populations often grow as their prey becomes more abundant, which makes them even more effective as control agents

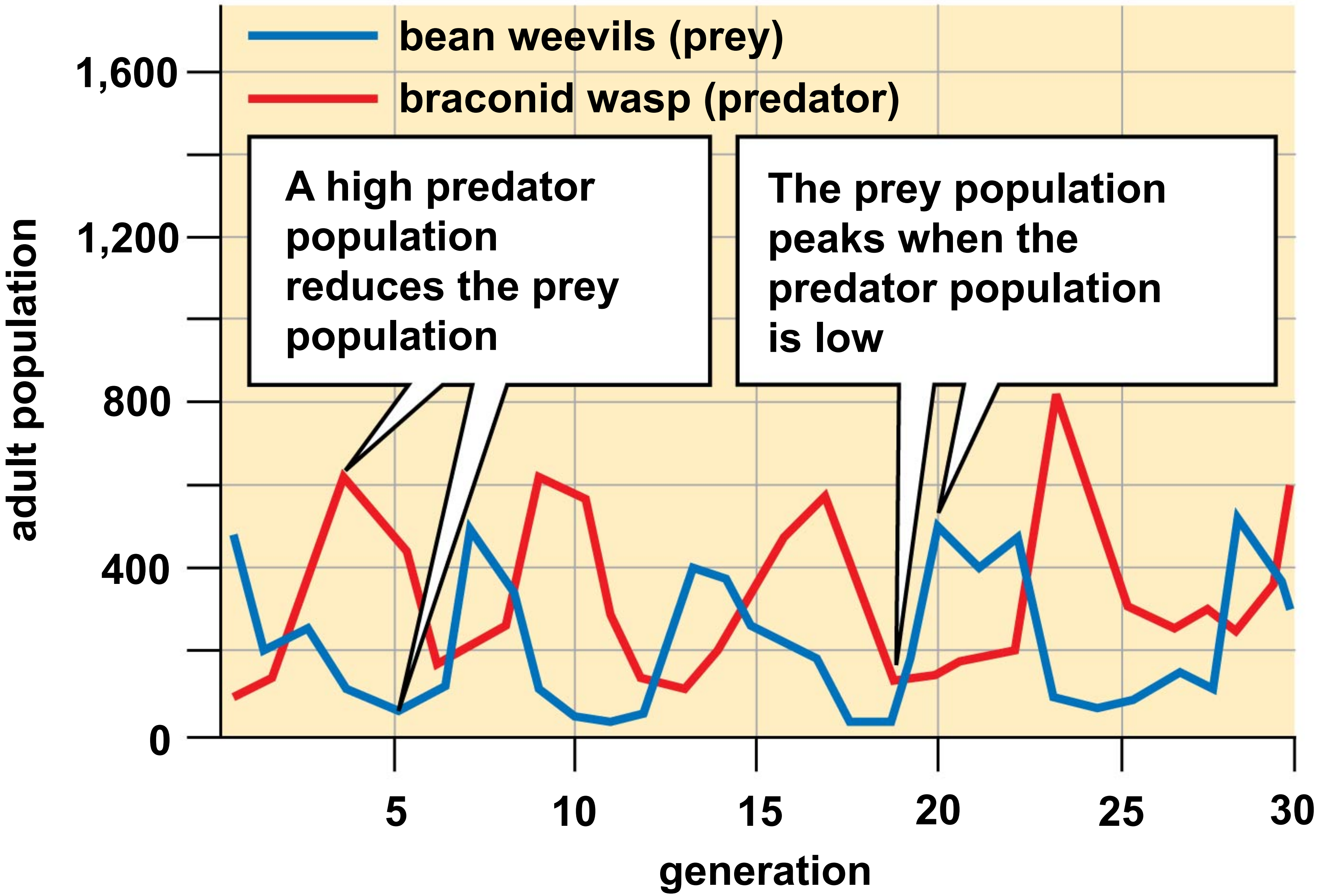
Figure 26-8b Predator populations often increase when prey are abundant

(b) Predator populations often increase when prey are abundant

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Predators exert density-dependent controls on populations *(continued)*
      - Some predator-prey **population cycles** are out-of-phase when predators cause a dramatic decline in prey populations, which in turn results in a decline in the predator population at a future date

Figure 26-9 Experimental predator–prey cycles



26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Parasites spread more rapidly among dense populations
      - A **parasite** feeds on a larger organism, its **host**, harming it
      - Parasites include tapeworms that live in the intestines of mammals, ticks that cling to the host's skin, and disease-causing microorganisms

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Parasites spread more rapidly among dense populations *(continued)*
      - Parasites, like predators, more often contribute to the death of less-fit individuals, producing a balance in which the host population is regulated but not eliminated

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Competition for resources helps control populations
      - **Competition** is the interaction among individuals who attempt to use the same limited resource, which limits population size in a density-dependent manner

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Competition for resources helps control populations *(continued)*
      - Most plants and many insects engage in **scramble competition**—a free-for-all scramble as individuals try to beat others to a limited pool of resources

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Competition for resources helps control populations *(continued)*
      - For example, gypsy moth females each lay a mass of up to 1,000 eggs on tree trunks in eastern North America

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Competition for resources helps control populations *(continued)*
      - As the eggs hatch, armies of caterpillars crawl up the tree
        - Huge outbreaks of this invasive species can completely strip large trees of their leaves in a few days
        - Competition for food may be so great that most of the caterpillars die before they can metamorphose into egg-laying moths

Figure 26-10 Scramble competition

(a) Gypsy moths laying eggs **(b) Gypsy moths caterpillars**

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Competition for resources helps control populations *(continued)*
      - Many animals have evolved **contest competitions**, where social or chemical interactions determine access to important resources
      - Territorial species—such as wolves, fish, rabbits, and songbirds—defend areas that contain important resources
      - Only the best adapted individuals are able to defend their territories that supply adequate food and shelter

26.2 How Is Population Growth Regulated?

- Environmental resistance limits population growth *(continued)*
  - Density-dependent factors become more effective as population density increases *(continued)*
    - Competition for resources helps control populations *(continued)*
      - As population densities increase and competition becomes more intense, some animals react by emigrating

26.3 How Are Populations Distributed in Space and Age?

- Populations of different types of organisms show characteristic spacing of their members, determined by their behavioral characteristics and their environments
- Each population exhibits patterns of reproduction and survival that are characteristic of its species

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions
  - *Spatial distribution* describes how individuals within a population are distributed within a given area
  - Spatial distribution may vary with time, changing with the breeding seasons
  - Ecologists recognize three major types of spatial distribution:
    - Clumped
    - Uniform
    - Random

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions *(continued)*
  - Populations whose members live in groups exhibit **clumped distribution**
    - Examples include elephant herds, wolf packs, prides of lions, flocks of birds, and schools of fish

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions *(continued)*
  - Advantages of clumped distributions include
    - Many eyes that can search for localized food sources
    - Movement of the group (e.g., schools of fish or flocks of birds) can confuse predators by their sheer numbers
    - Predators, in turn, may hunt in groups, cooperating to bring down larger prey

(a) Clumped distribution

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions *(continued)*
  - Organisms with a **uniform distribution** maintain a relatively constant distance between individuals
    - This is common among territorial animals defending scarce resources or breeding territories
      - An example among plants is desert creosote bushes, which are spaced evenly resulting from competition among their root systems for water and nutrients

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions *(continued)*
  - Territorial behavior is more common among animals during their breeding seasons
    - Seabirds may space their nests evenly along the shore, just out of reach of one another
    - Mature desert creosote bushes are often spaced very evenly
      - This spacing comes from competition among their root systems, which occupy a circular area around each plant

Figure 26-12b Uniform distribution

(b) Uniform distribution

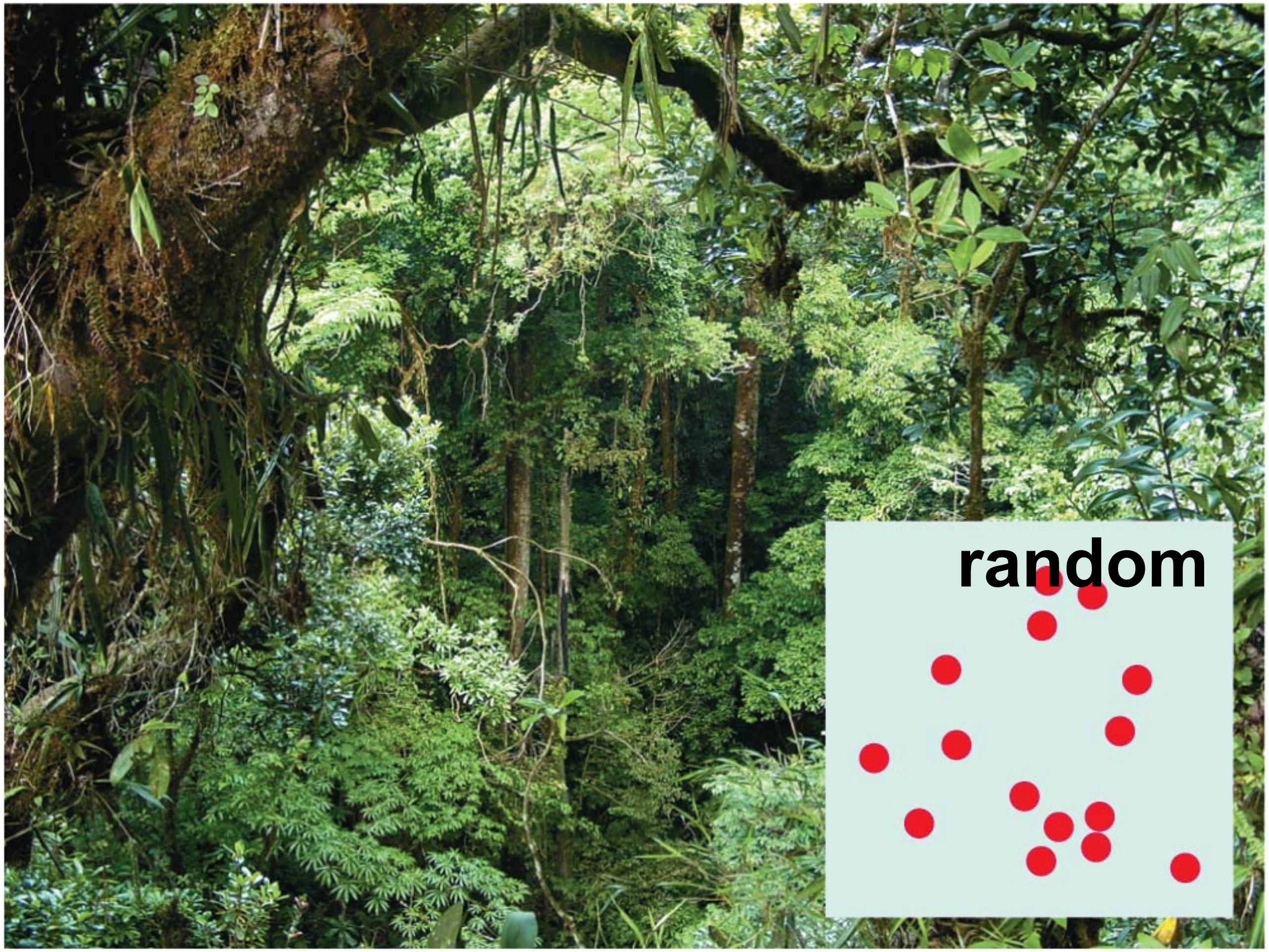
26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions *(continued)*
  - Organisms with a **random distribution** are relatively rare
    - Such individuals do not form social groups
    - The resources needed are more or less equally available throughout the area they inhabit
      - Resources are not scarce enough to require territorial spacing
      - Examples include trees and other plants in rain forests

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different spatial distributions *(continued)*
  - There are probably no vertebrate species that maintain a random distribution throughout the year
  - Most interact socially, at least during the breeding season

Figure 26-12c Random distribution



(c) Random distribution

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions
  - Animals of different species differ considerably in their chances of dying at any given phase of their life cycle
    - Some species produce many offspring that are provided with very few resources; most die before they can reproduce
    - Others produce few offspring, which are each given far more resources and often survive to reproduce

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions *(continued)*
  - Three types of survivorship curves are described according to the part of the life cycle during which most deaths occur
    - Late-loss populations
    - Constant-loss populations
    - Early-loss populations

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions *(continued)*
  - To determine the pattern of survivorship, researchers construct **survivorship tables**, which track groups of organisms (born at the same time) throughout their lives, recording how many survive in each succeeding year
  - If these numbers are graphed, they reveal the **survivorship curves** characteristic of the species in the environment where the data were collected

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions *(continued)*
  - **Late-loss populations** produce convex survivorship curves
    - These populations have relatively low juvenile death rates; many or most individuals survive to old age
    - Late-loss curves are characteristic of humans and other large and long-lived animals such as elephants and mountain sheep
    - Relatively few offspring are produced by these species

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions *(continued)*
  - **Constant-loss populations** produce straight-line survivorship curves
    - In these populations, individuals have an equal chance of dying at any time during their life span
      - This pattern is seen in some birds such as gulls and the American robin, in some species of turtles, and in laboratory populations of organisms that reproduce asexually, such as hydra and bacteria

26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions *(continued)*
  - **Early-loss populations** produce concave survivorship curves
    - These curves are characteristic of organisms that produce large numbers of offspring that receive little or no parental care
    - Many of these species engage in scramble competition early in life

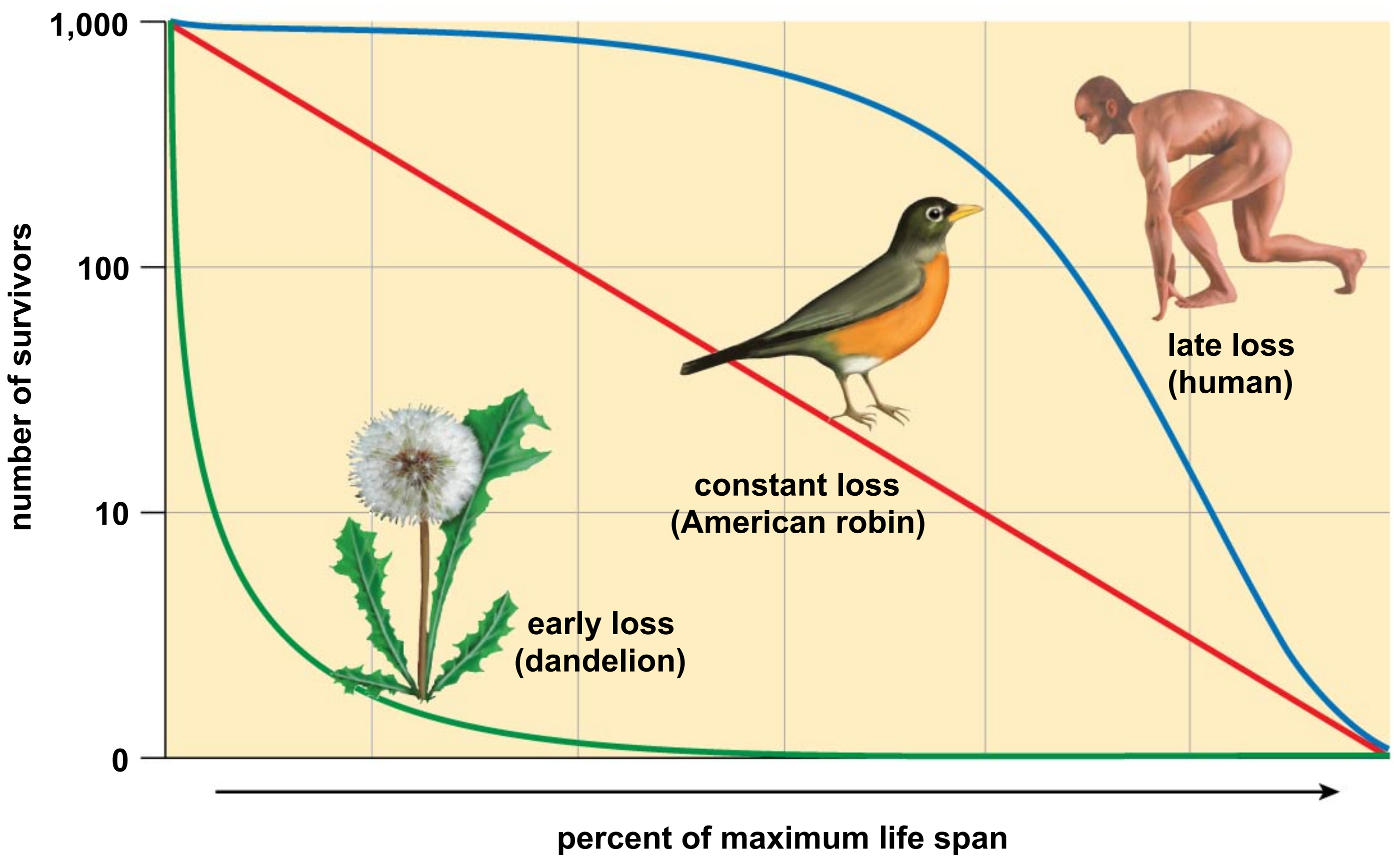
26.3 How Are Populations Distributed in Space and Age?

- Populations exhibit different age distributions *(continued)*
  - **Early-loss populations** produce concave survivorship curves *(continued)*
    - The death rate is high among the young, but those that reach adulthood have a reasonable chance to survive to old age
      - Most invertebrates, many fish and amphibians, and most plants exhibit early loss survivorship curves

Figure 26-13 Survivorship tables and survivorship curves

Age	Number of survivors
0 (birth)	100,000
10	99,124
20	98,713
30	97,754
40	96,489
50	93,698
60	87,967
70	76,241
80	54,117
90	22,312
100	2,523

(a) A survivorship table



(b) Survivorship curves

26.4 How Is the Human Population Changing?

- No force on Earth rivals that exerted by humans
  - Humans possess enormous brainpower
    - We possess dexterous hands that can shape the environment by our demands
- Natural selection favored those with the ability and the drive to bear and nurture offspring, which helped make sure that few would survive
  - This characteristic now threatens us and the biosphere on which we depend

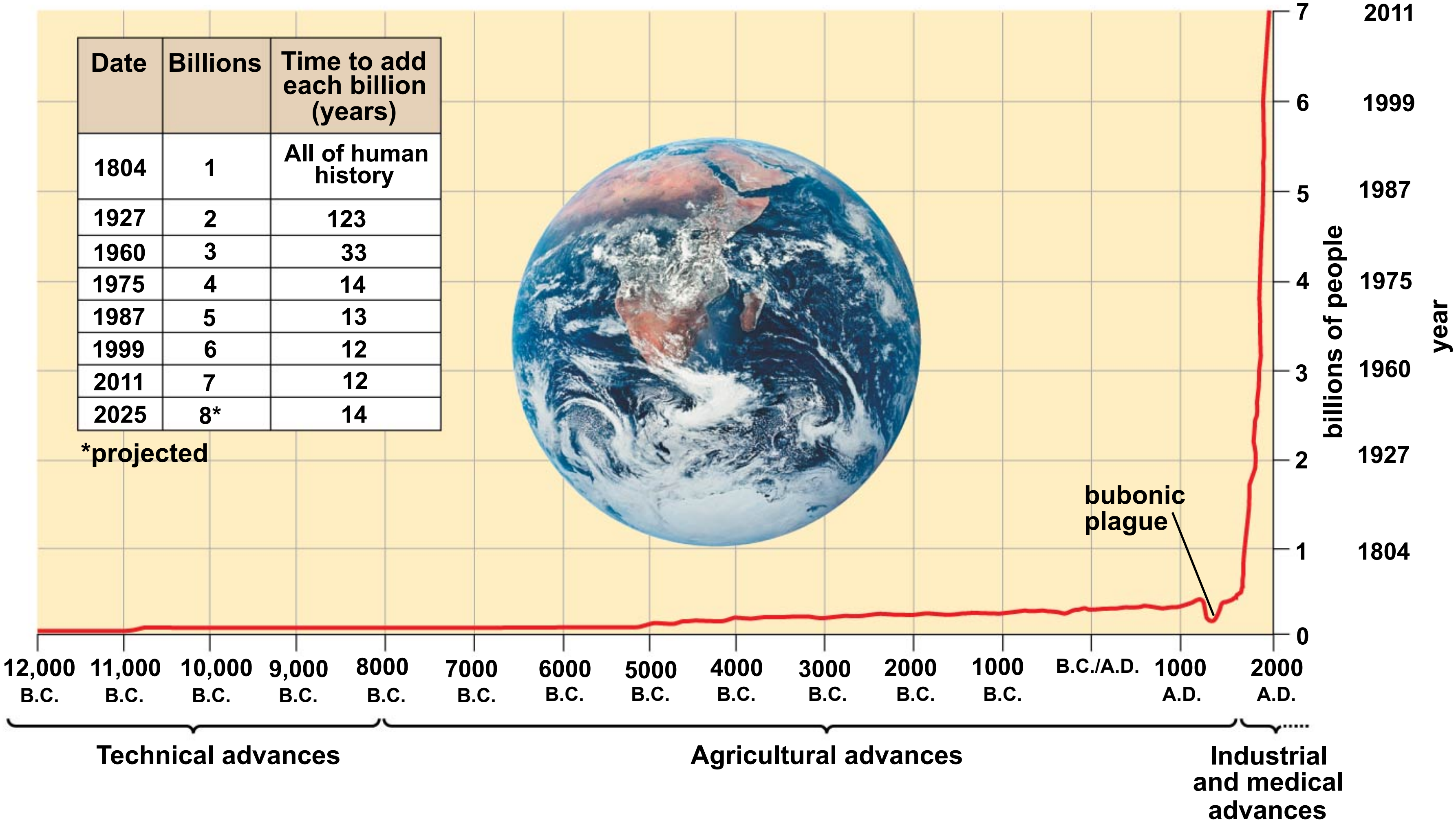
26.4 How Is the Human Population Changing?

- The human population continues to grow rapidly
  - In the last few centuries, the human population has grown at nearly an exponential rate following a J-shaped growth curve
  - Over the last decade, however, the human population has been growing at a relatively constant rate, suggesting that it may no longer be growing exponentially

26.4 How Is the Human Population Changing?

- The human population continues to grow rapidly *(continued)*
  - Are humans starting to enter the final bend of the S-shaped logistic growth curve that will eventually lead to a stable population?
    - Despite the fact that our annual growth rate has declined from 1.8% in 1960 to 1.2% in 2011, Earth's human population is adding people faster than ever
    - Having reached 7 billion in 2011, our numbers now grow by about 83 million each year

Figure 26-14 Human population growth



Date	Billions	Time to add each billion (years)
1804	1	All of human history
1927	2	123
1960	3	33
1975	4	14
1987	5	13
1999	6	12
2011	7	12
2025	8*	14

*projected

26.4 How Is the Human Population Changing?

- A series of advances has increased Earth's carrying capacity to support people
  - Human population growth has been spurred by a series of advances, each of which circumvented some type of environmental resistance, increasing Earth's carrying capacity for people

26.4 How Is the Human Population Changing?

- A series of advances has increased Earth’s carrying capacity to support people *(continued)*
  - Early humans
    - Discovered fire
    - Invented tools and weapons
    - Built shelters
    - Designed protective clothing

26.4 How Is the Human Population Changing?

- A series of advances has increased Earth's carrying capacity to support people *(continued)*
  - Human population growth continued slowly for thousands of years until major *industrial and medical advances* permitted a population explosion
    - These advances began in England in the mid-eighteenth century
    - Medical progress dramatically decreased the death rate by reducing environmental resistance caused by disease

26.4 How Is the Human Population Changing?

- A series of advances has increased Earth's carrying capacity to support people *(continued)*
  - The discovery of bacteria and their role in infection resulted in better control of bacterial diseases through improved sanitation and antibiotics
  - Vaccines for diseases such as smallpox reduced deaths from viral infections

26.4 How Is the Human Population Changing?

- The demographic transition explains trends in population size
  - In **developed countries**, people benefit from a relatively high standard of living, with access to modern technology and medical care, including readily available contraception
    - Developed countries include Australia, New Zealand, Japan, and countries in North America and Europe

26.4 How Is the Human Population Changing?

- The demographic transition explains trends in population size *(continued)*
  - Average income in developed countries is relatively high
  - Education and employment opportunities are available to both sexes
  - Death rates from infectious diseases are low
  - Less than 20% of the world's population lives in developed countries

26.4 How Is the Human Population Changing?

- The demographic transition explains trends in population size *(continued)*
  - In the **developing countries** of Central and South America, Africa, and much of Asia—home to more than 80% of humanity—the average person lacks these advantages
  - The historical rate of population growth in developed countries has changed over time in reasonably predictable stages, producing a pattern called **demographic transition**

26.4 How Is the Human Population Changing?

- The demographic transition explains trends in population size *(continued)*
  - A population's *fertility rate* reflects the average number of children that each woman bears
  - If immigration and emigration rates are balanced, a population will eventually stabilize if parents have just the number of children to replace themselves
    - This is called **replacement-level fertility** (**RLF**)
    - RLF is 2.1 children per woman because not all children survive to maturity

26.4 How Is the Human Population Changing?

- World population growth is unevenly distributed
  - In developing countries, medical advances have decreased death rates and increased life span, but birth rates remain relatively high
  - Although China is a developing country, its population has approached one billion

26.4 How Is the Human Population Changing?

- World population growth is unevenly distributed *(continued)*
  - Most other developing countries are within the late-transitional or the industrial stage of the demographic transition
    - Adult children provide financial security for aging parents
    - Young children may also contribute significantly to the family income by working on farms or factories

26.4 How Is the Human Population Changing?

- World population growth is unevenly distributed *(continued)*
  - A lack of education and a lack of access to contraceptives then contributes to continued high birth rates
    - Of the 7 billion people on Earth in 2011, about 5.8 billion resided in developing countries
    - The prospect for world population stabilization in the near future is nonexistent

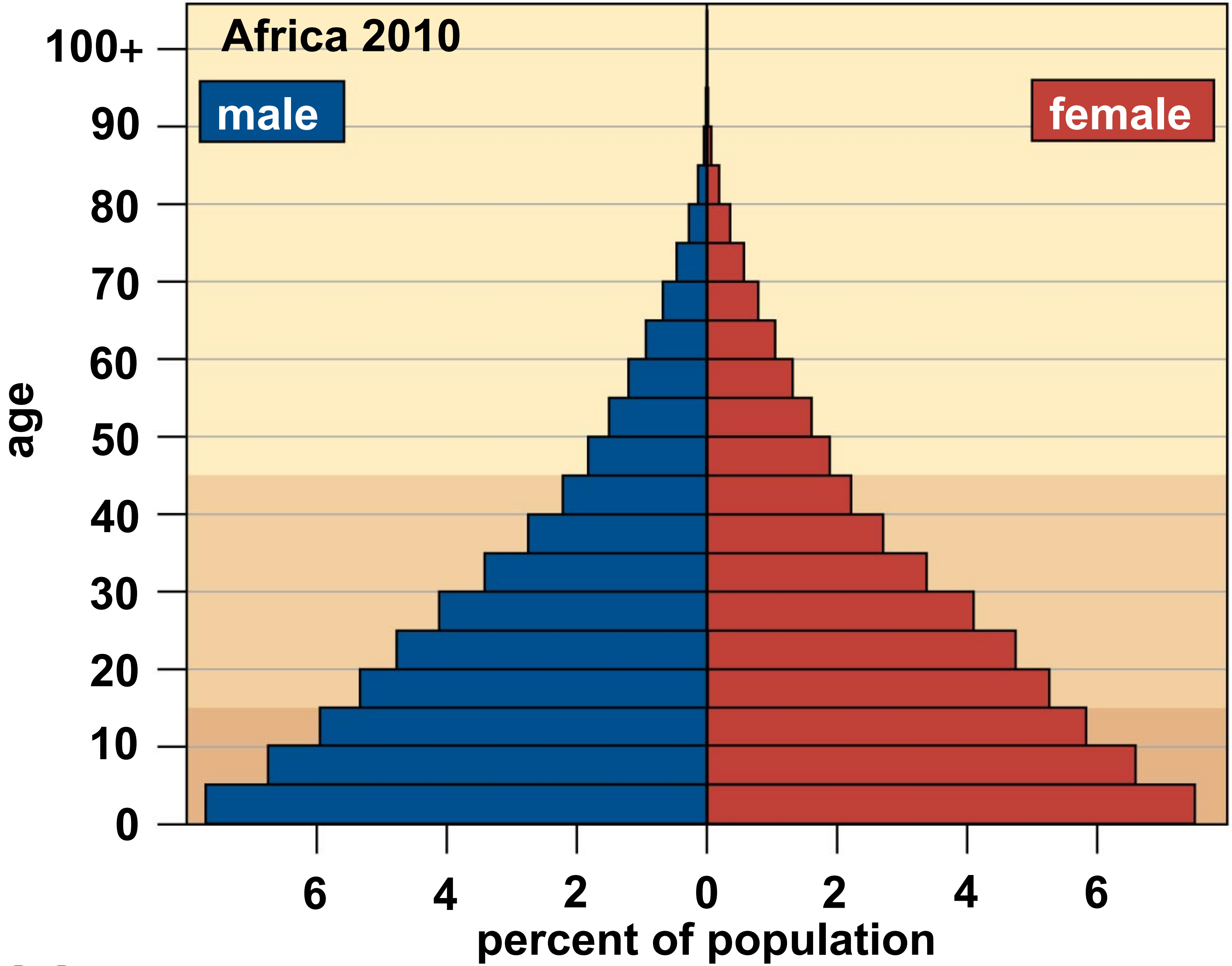
26.4 How Is the Human Population Changing?

- The age structure of a population predicts its future growth
  - **Age structure diagrams** show age groups on the vertical axis and the numbers (or percentages) of individuals in each age group on the horizontal axis, with males and females shown on opposite sides
  - Age structure diagrams all rise to a peak that reflects the maximum human life span
  - The shape of the rest of the diagram reveals whether the population is expanding, stable, or shrinking

26.4 How Is the Human Population Changing?

- The age structure of a population predicts its future growth *(continued)*
  – If adults of reproductive age (15 to 44 years) are having more children (the 0- to 14-year age group) than are needed to replace themselves, the population is above RLF and is expanding
    – The age-structure diagram will be roughly triangular

Figure 26-16a Africa: A rapidly growing population

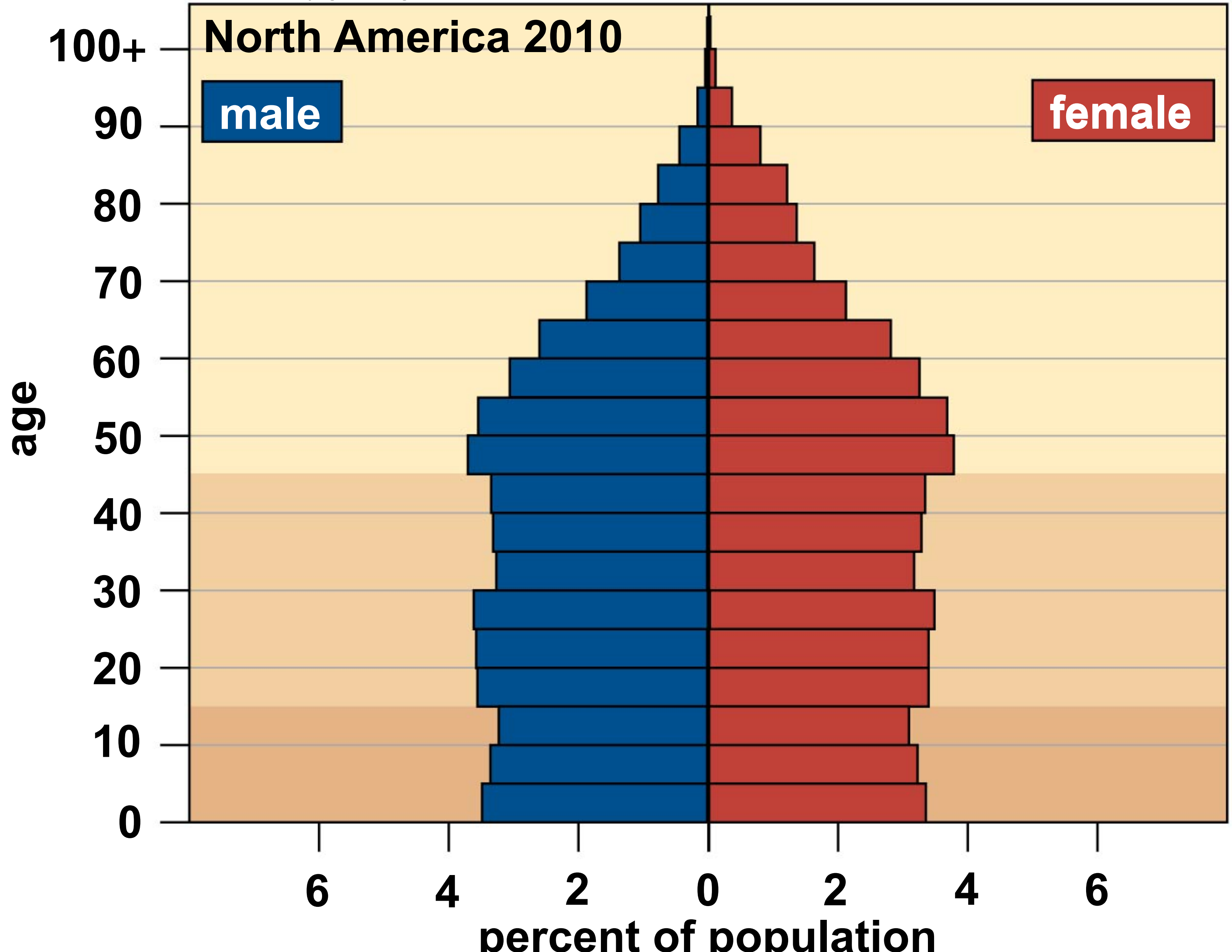


(a) Africa: A rapidly growing population

26.4 How Is the Human Population Changing?

- The age structure of a population predicts its future growth *(continued)*
  – If adults of reproductive age have just the number of children needed to replace themselves, the population is at RLF
    – A population that has been at RLF for many years will have an age structure diagram with relatively straight sides

Figure 26-16b North America: A slowly growing population

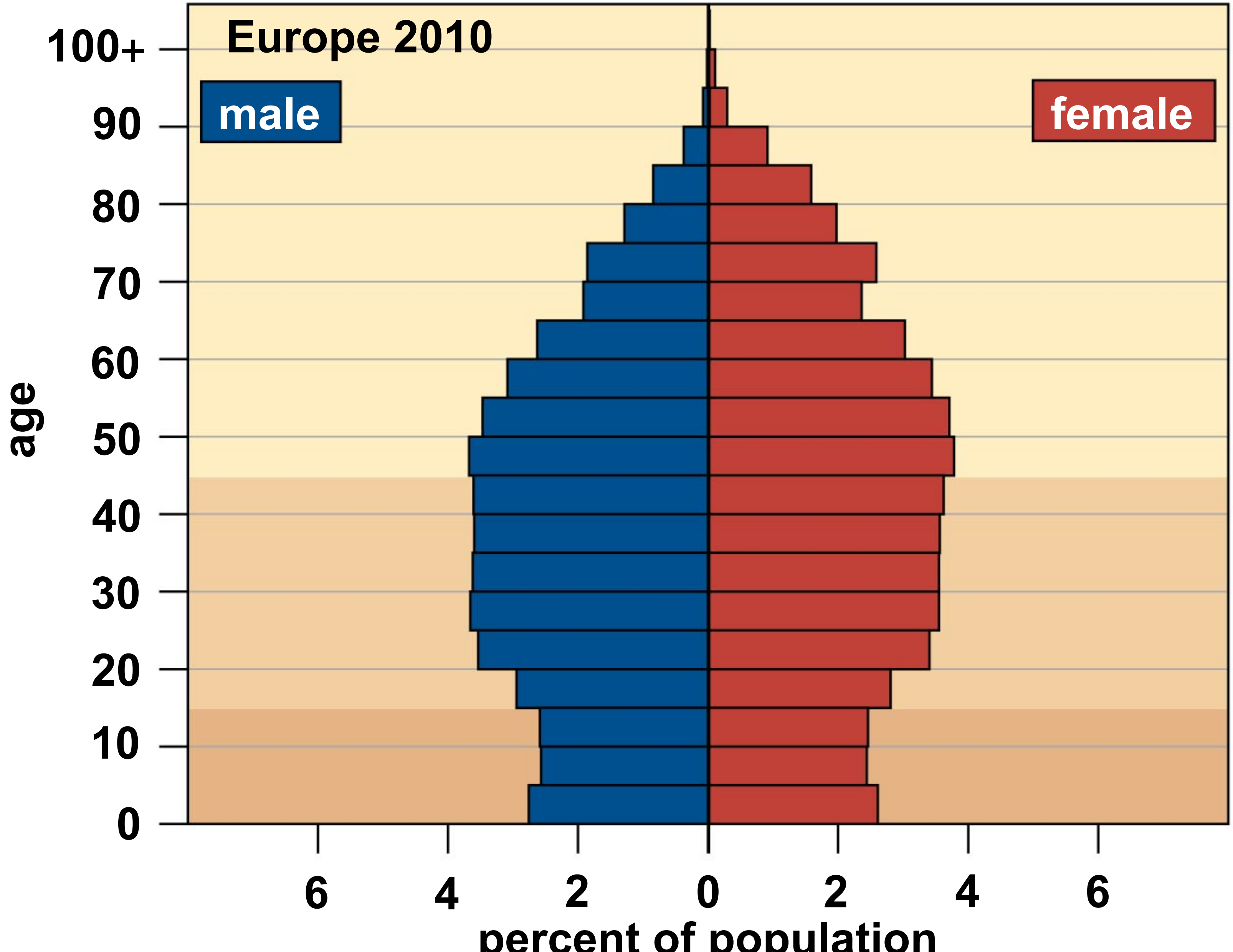


(b) North America: A slowly growing population

26.4 How Is the Human Population Changing?

- The age structure of a population predicts its future growth *(continued)*
  – In a shrinking population, the reproducing adults have fewer children than are required to replace themselves
    – The age-structure diagram will be narrow at the base
      – The *median age* depends on the age structure
      – The lower the median age, the more rapidly the population will expand

Figure 26-16c Europe: A slowly declining population



(c) Europe: A slowly declining population

26.4 How Is the Human Population Changing?

- The age structure of a population predicts its future growth *(continued)*
  – Average-age structure diagrams have been plotted for developed and developing countries for 2012, with predictions for 2050